Reducing Design Cycle Time and Cost through Process Resequencing

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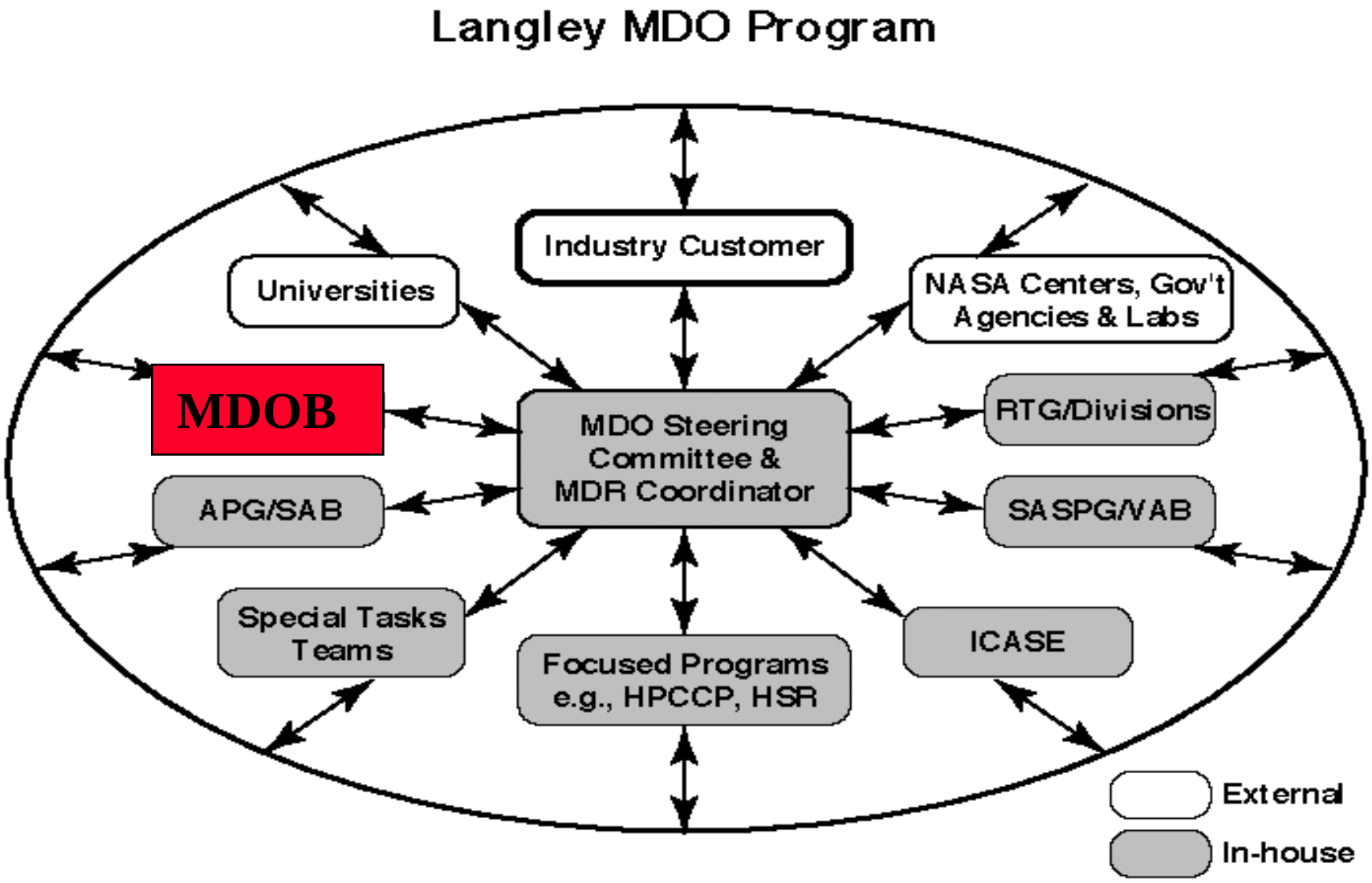
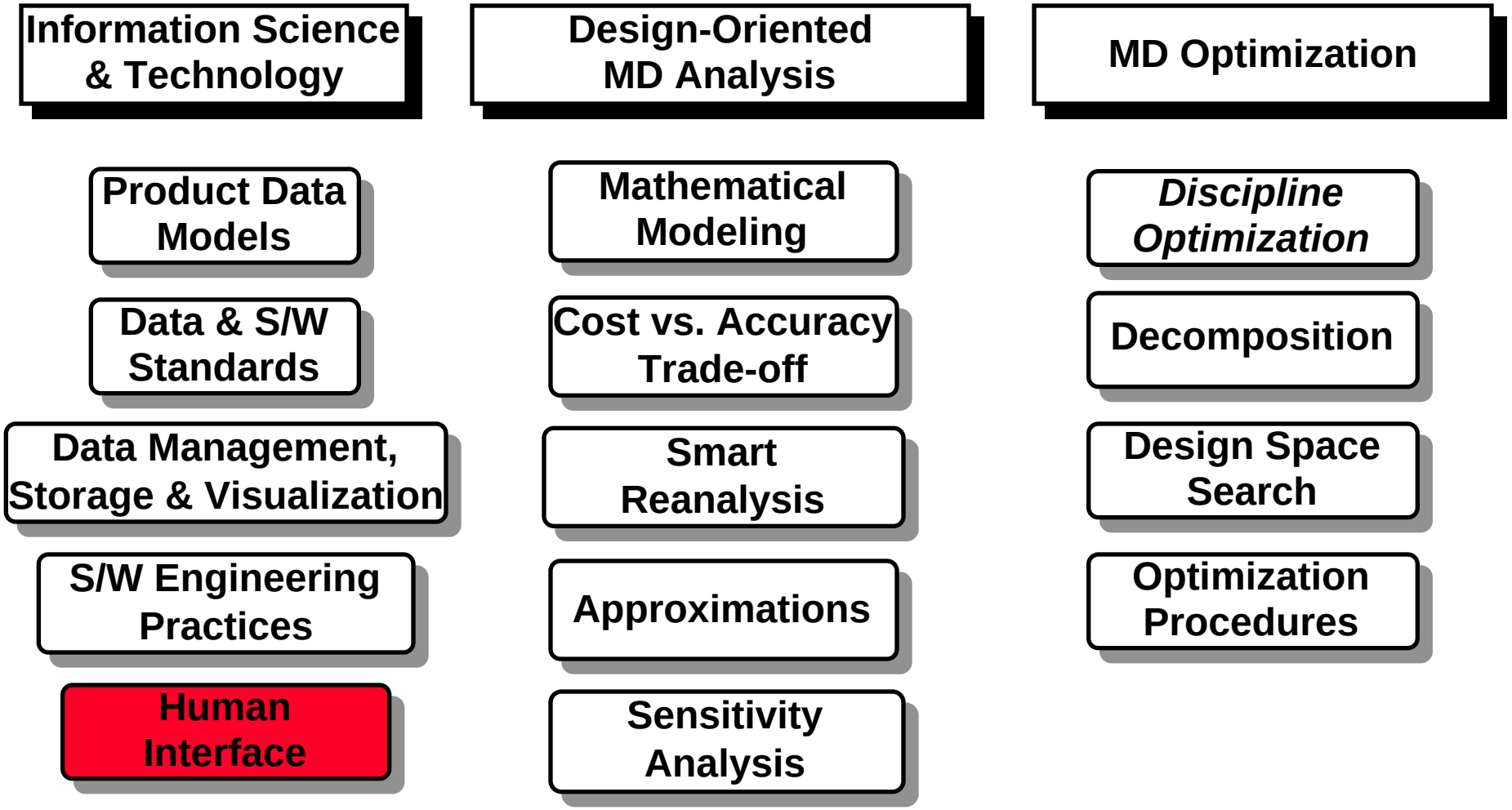
Definition of Multidisciplinary Design Optimization

Multidisciplinary Design Optimization (MDO) is a methodology for the design of complex engineering systems and subsystems that coherently exploits the synergism of mutually interacting disciplines.

NASA Langley Research Center
Multidisciplinary Optimization Branch



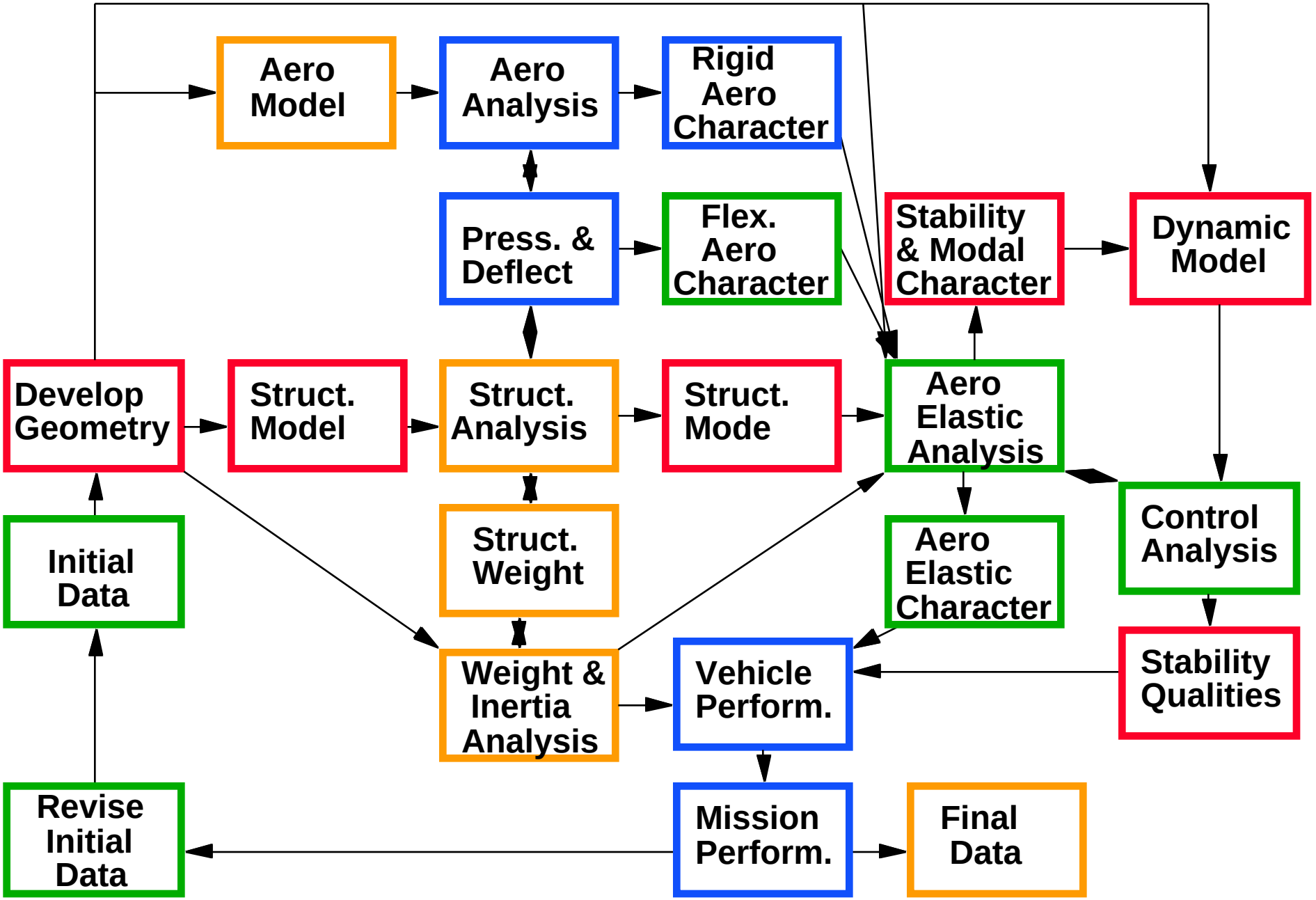
MDO Conceptual Elements



The Problem

In today’s competitive environment, companies are under enormous pressure to reduce the time and cost of their design cycle.

Conceptual Design Process Flow



Design Manager's Aid for Intelligent Decomposition (DeMAID)

1989 DeMAID first available to the public

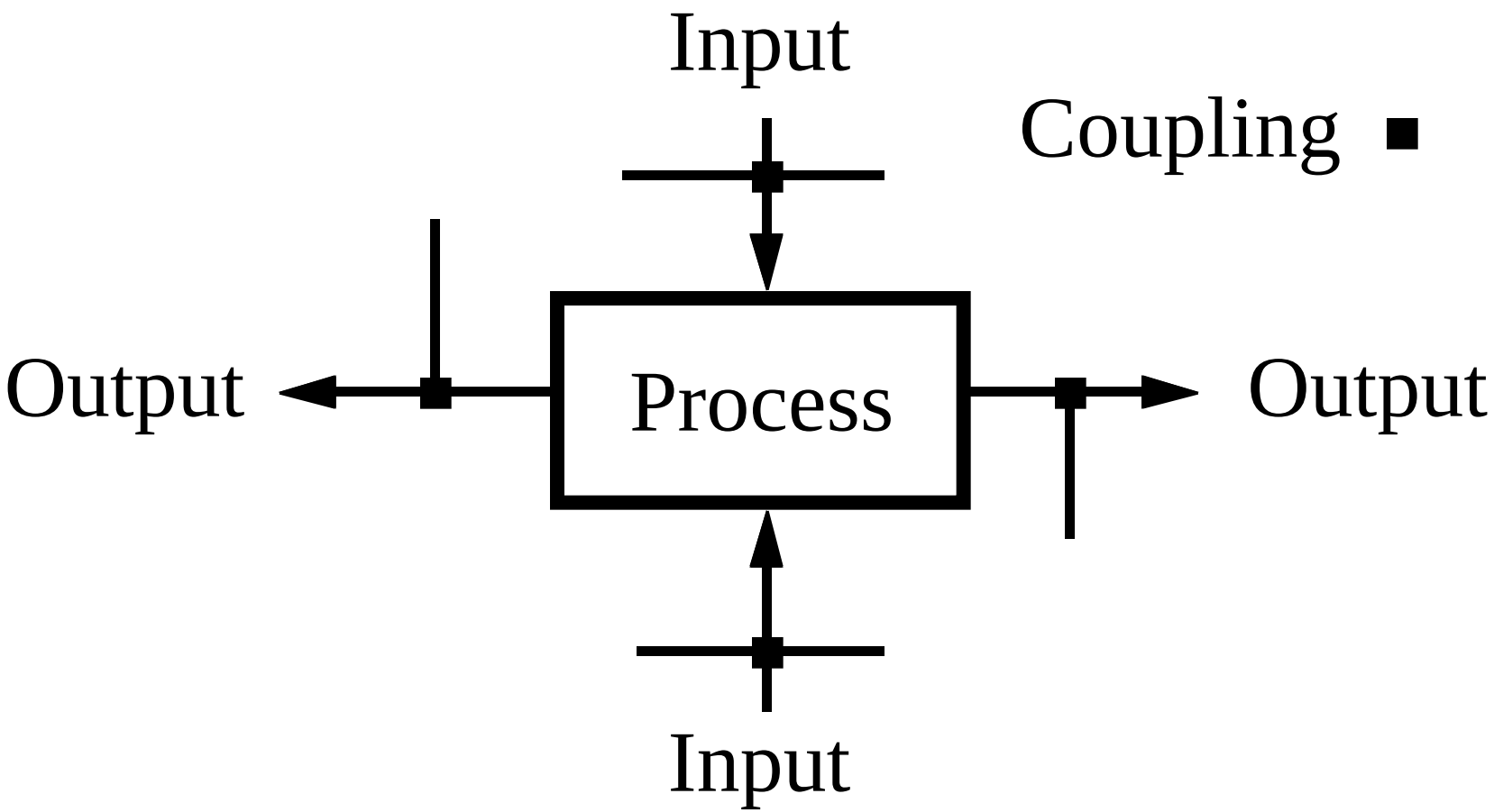
Knowledge-based system

Display with design structure matrix

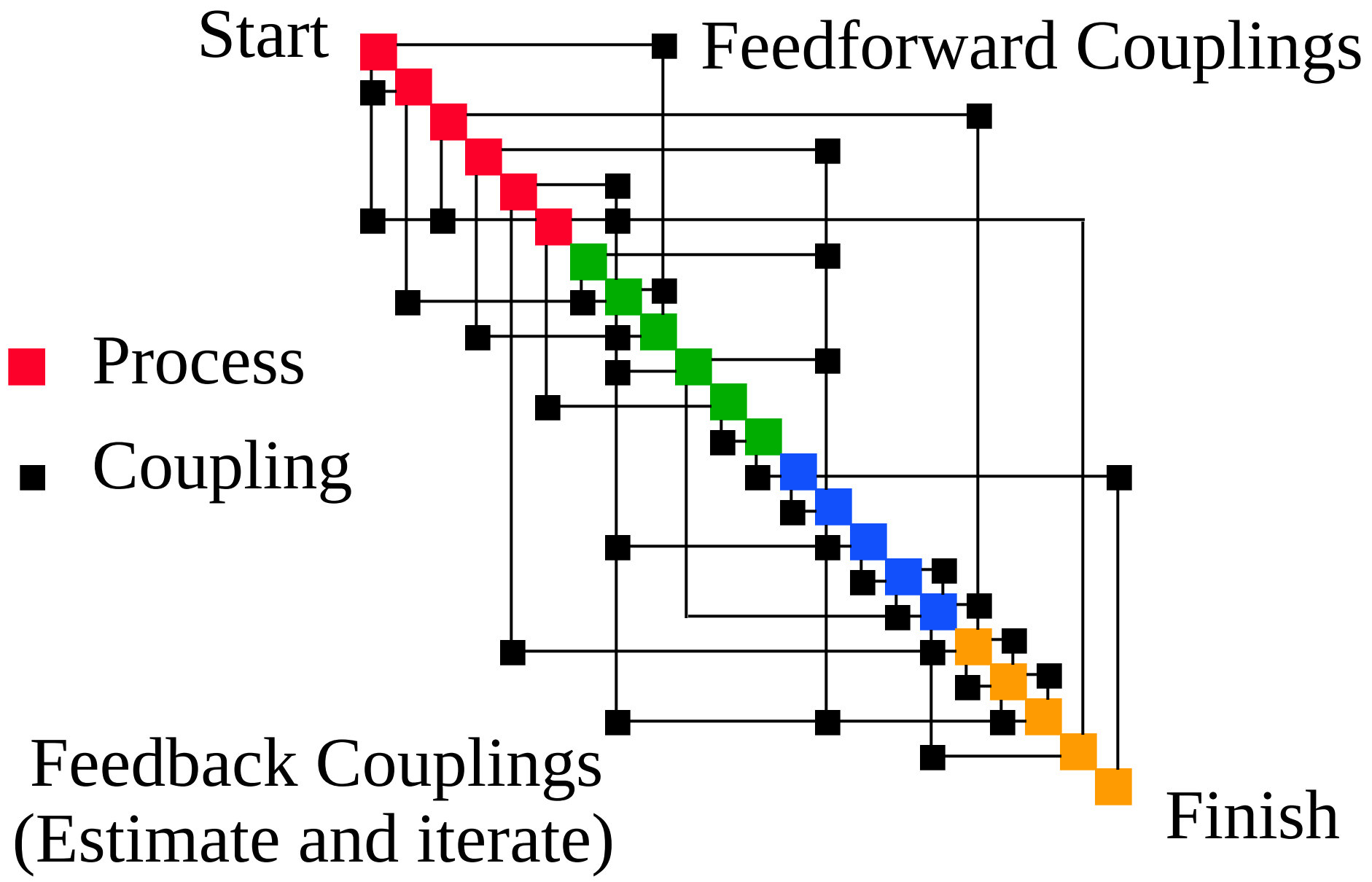
1996 Genetic algorithm added for sequencing

A Process

Output = Process (Input1, . . . , Inputn)
Time and cost associated with each process

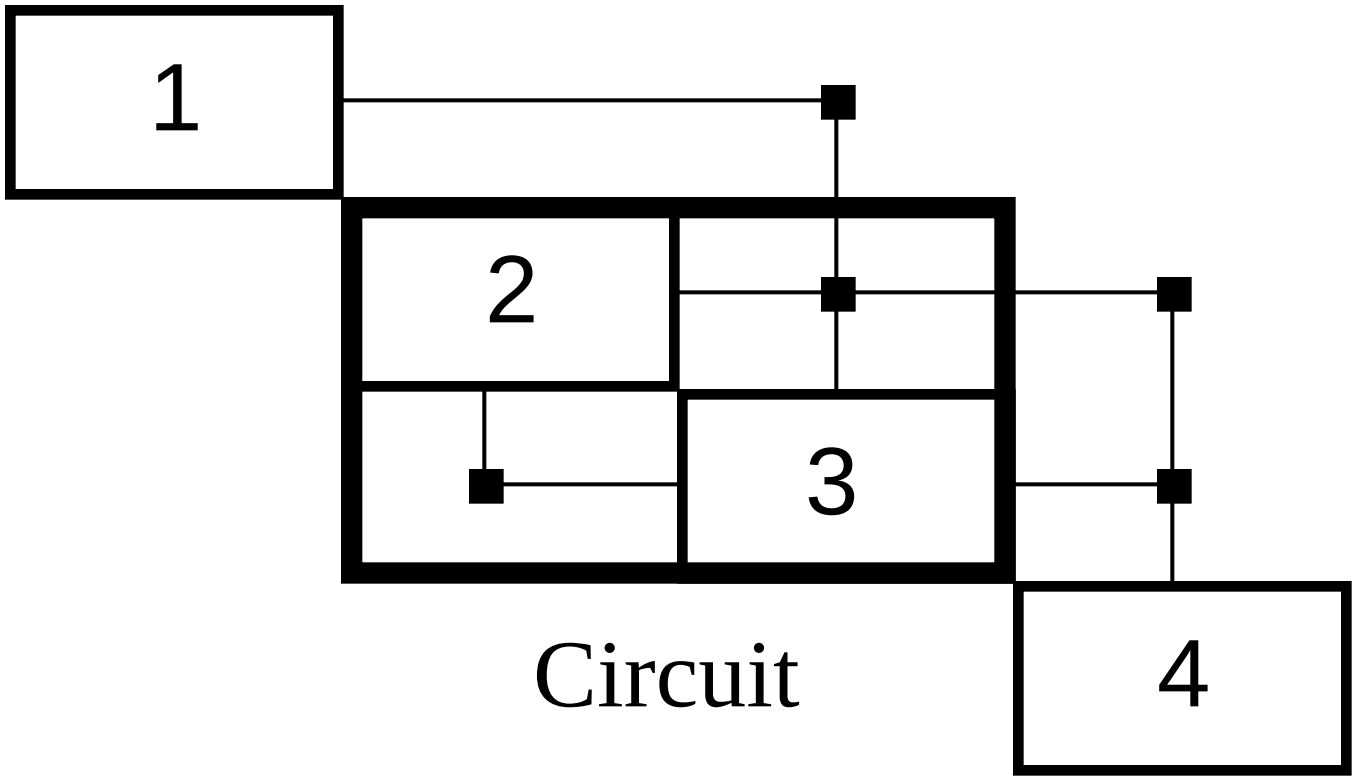


Design Structure Matrix



Design Structure Matrix - Circuit

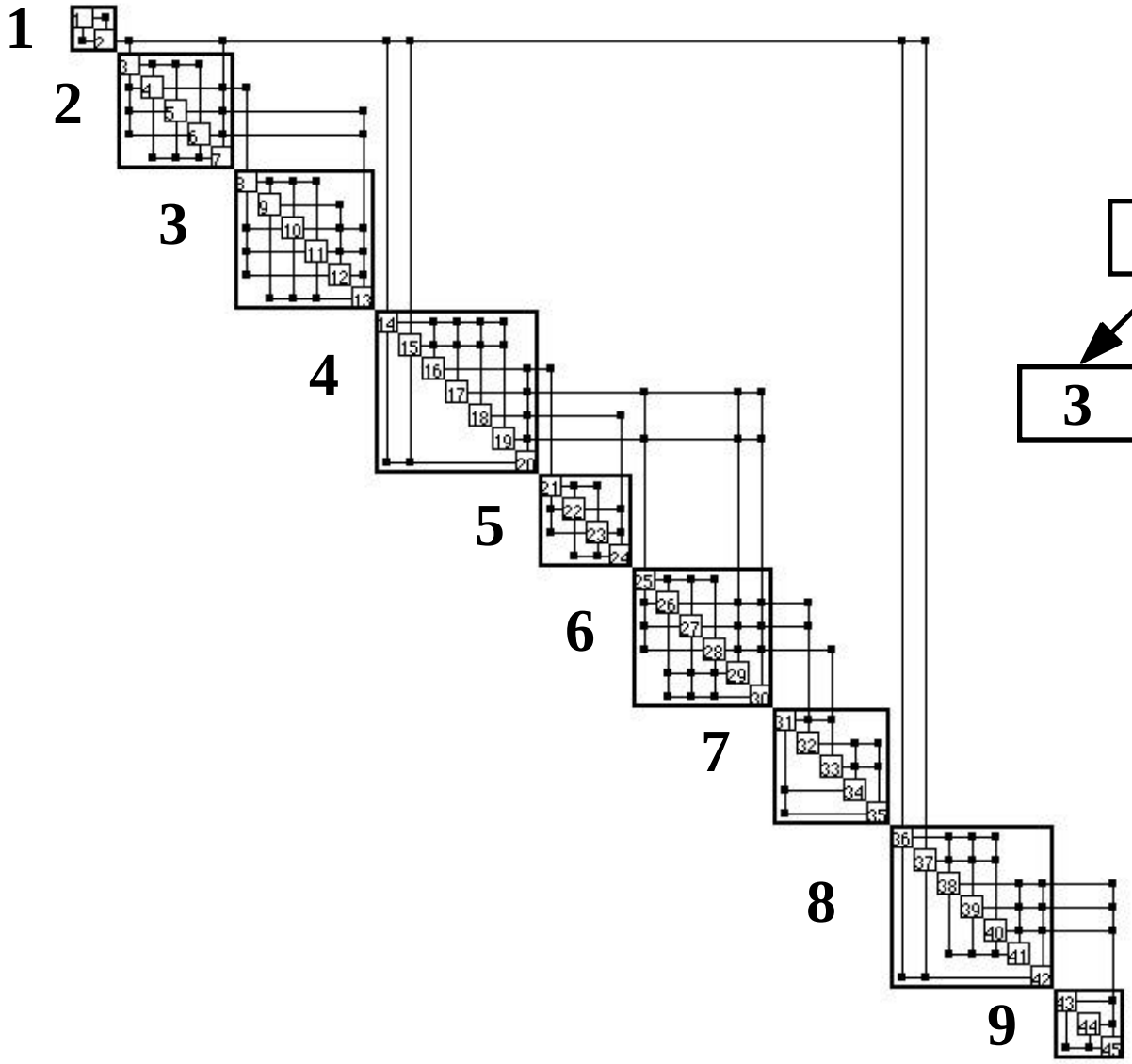
(Iterative Subcycle)

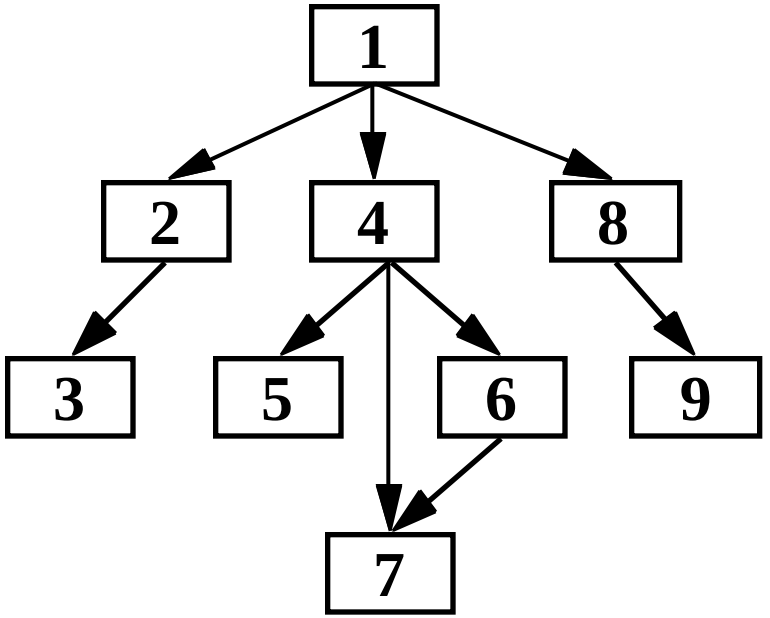


Techniques for Reducing Design Cycle Time and Cost

- Hierarchical decomposition
- Parallel processing vs. iteration reduction
- Changes in the design cycle
- Optimum sequencing with a genetic algorithm

Hierarchical Decomposition

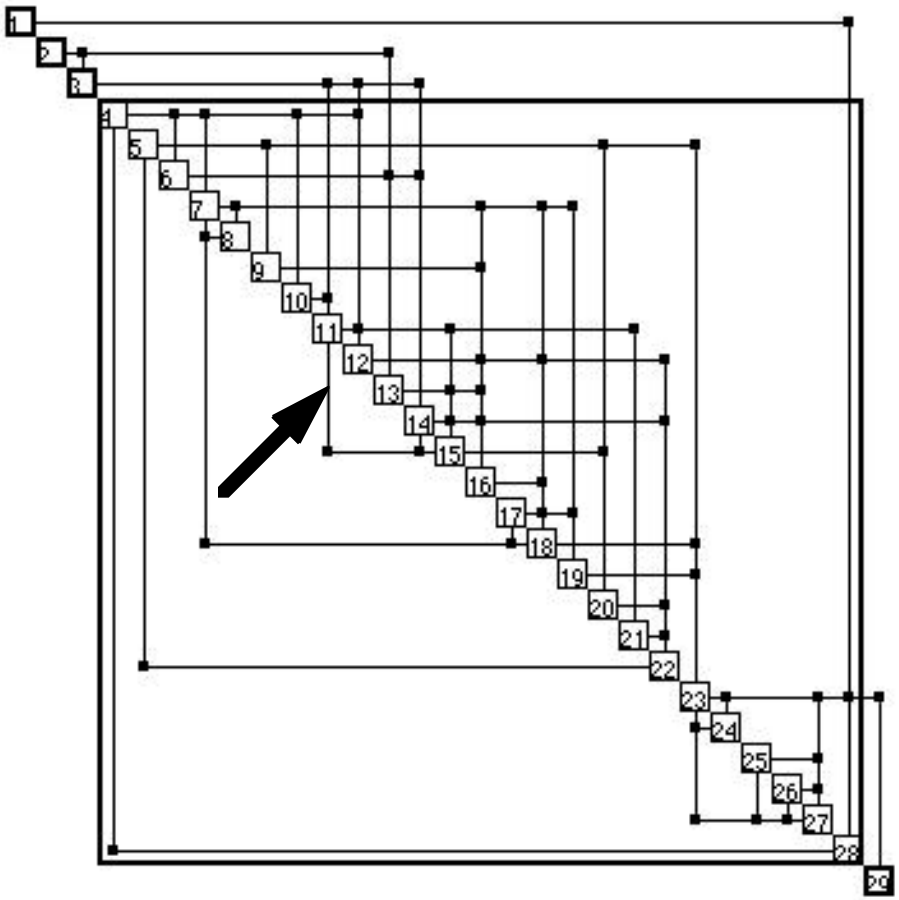




Trade-Off in Sequencing

Increase parallel processing or reduce iterations
Process 12 appears in 4 iterative loops

###	Label
1	initdv
2	mission
3	fltcond
4	geometry
5	stabmod
6	aromodel
7	propntgr
8	propdeck
9	dynmodel
10	strmodel
11	structre
12	wgtinert
13	arolndto
14	arocruse
15	prssdflt
16	controls
17	landto
18	mission
19	noise
20	aroflex
21	strmode
22	aroelast
23	optimize
24	objfun
25	mgf
26	support
27	cost
28	dsgnvar
29	finaldat



Parallel processes

4 5 17 25 26
6 7 9 10
8 11 13 14 19
12 15 21
16 20
18 22
23
24 27 28

Trade-Off in Sequencing

Increase parallel processing or reduce iterations
Process 12 appears in only 1 iterative loop

###	Label
1	initdv
2	mission
3	fltcond
4	geometry
6	aromodel
13	arolndto
10	stmodel
11	structre
15	prssdflt
14	arocruse
21	stmode
12	wgtinert
5	stabmod
20	aroflex
22	aroelast
9	dynmodel
8	propdeck
7	propntgr
16	controls
18	mission
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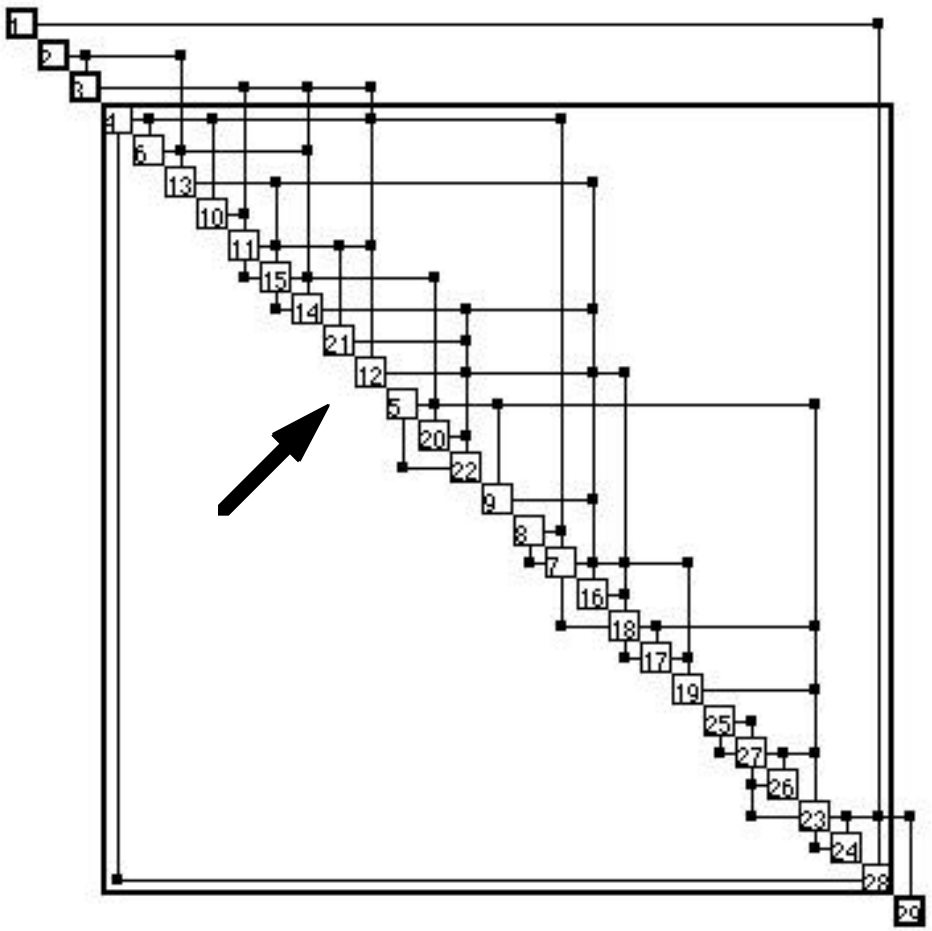
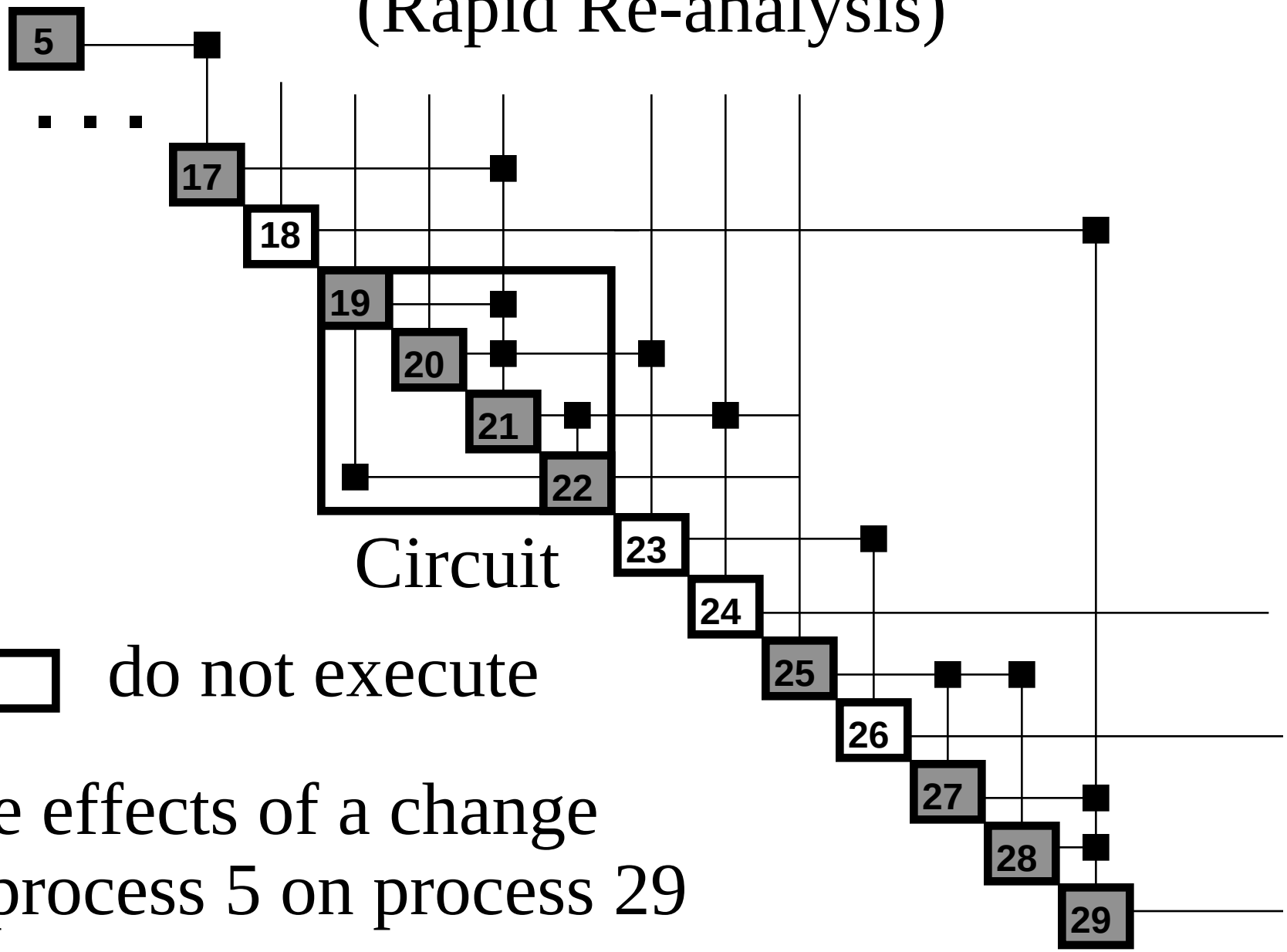


Parallel processes

4 5 8 25
6 7 9 10 27
11 13 26
12 15 21
14 20
16 22
18
17
19
24
23 28

Effects of a Design Cycle Change

(Rapid Re-analysis)

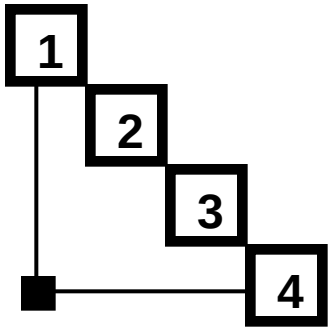


Circuit

do not execute

The effects of a change
to process 5 on process 29

Computing Design Cycle Time and Cost with a Genetic Algorithm



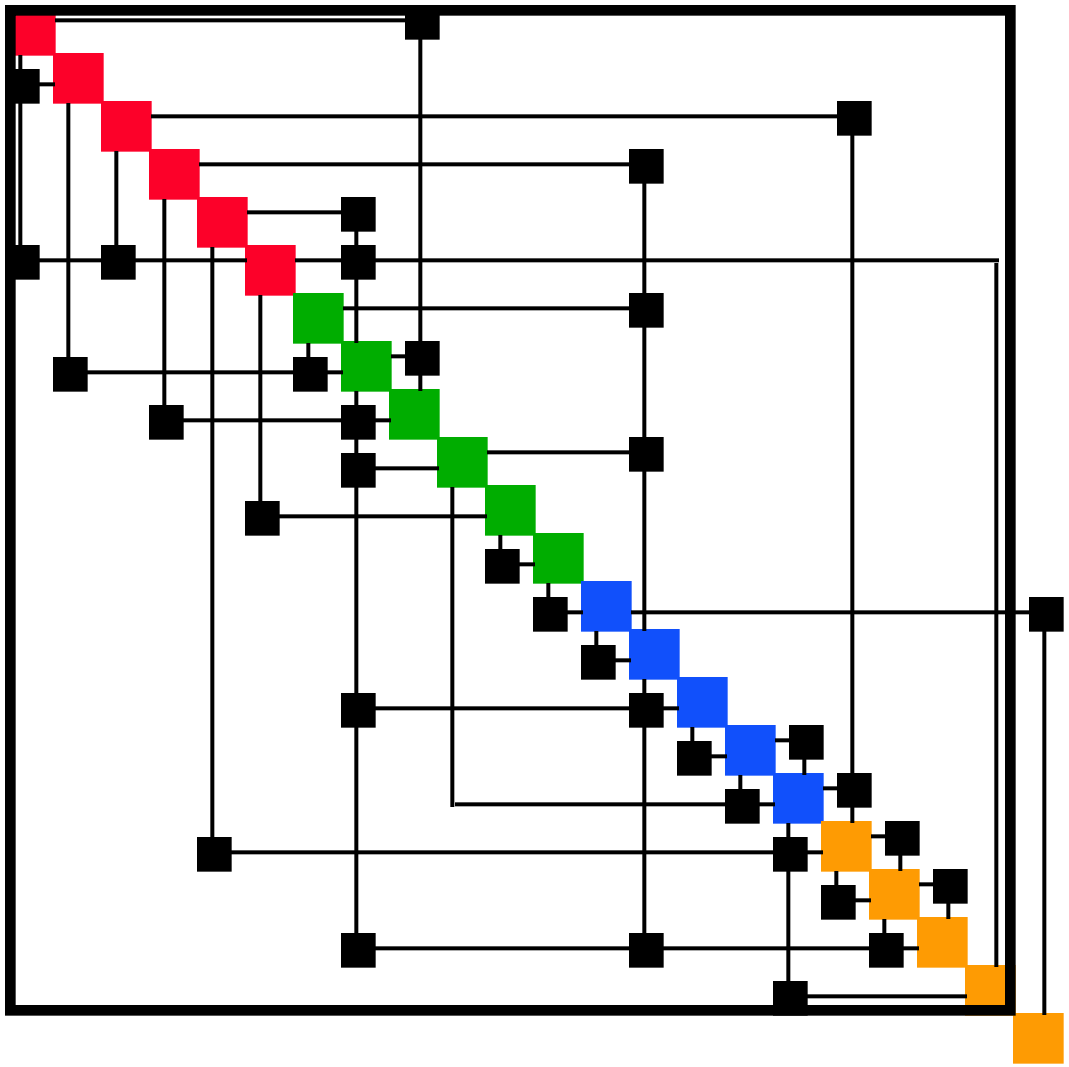
Time = 10 Cost = 20
Time = 30 Cost = 15
Time = 40 Cost = 40
Time = 20 Cost = 35

Number of iterations related to coupling strength
The stronger the coupling the more iterations
nominal = 5

Time = (10 + 30 + 40 + 20) * 5 = 500
Cost = (20 + 15 + 40 + 35) * 5 = 550

Design Cycle Time and Cost

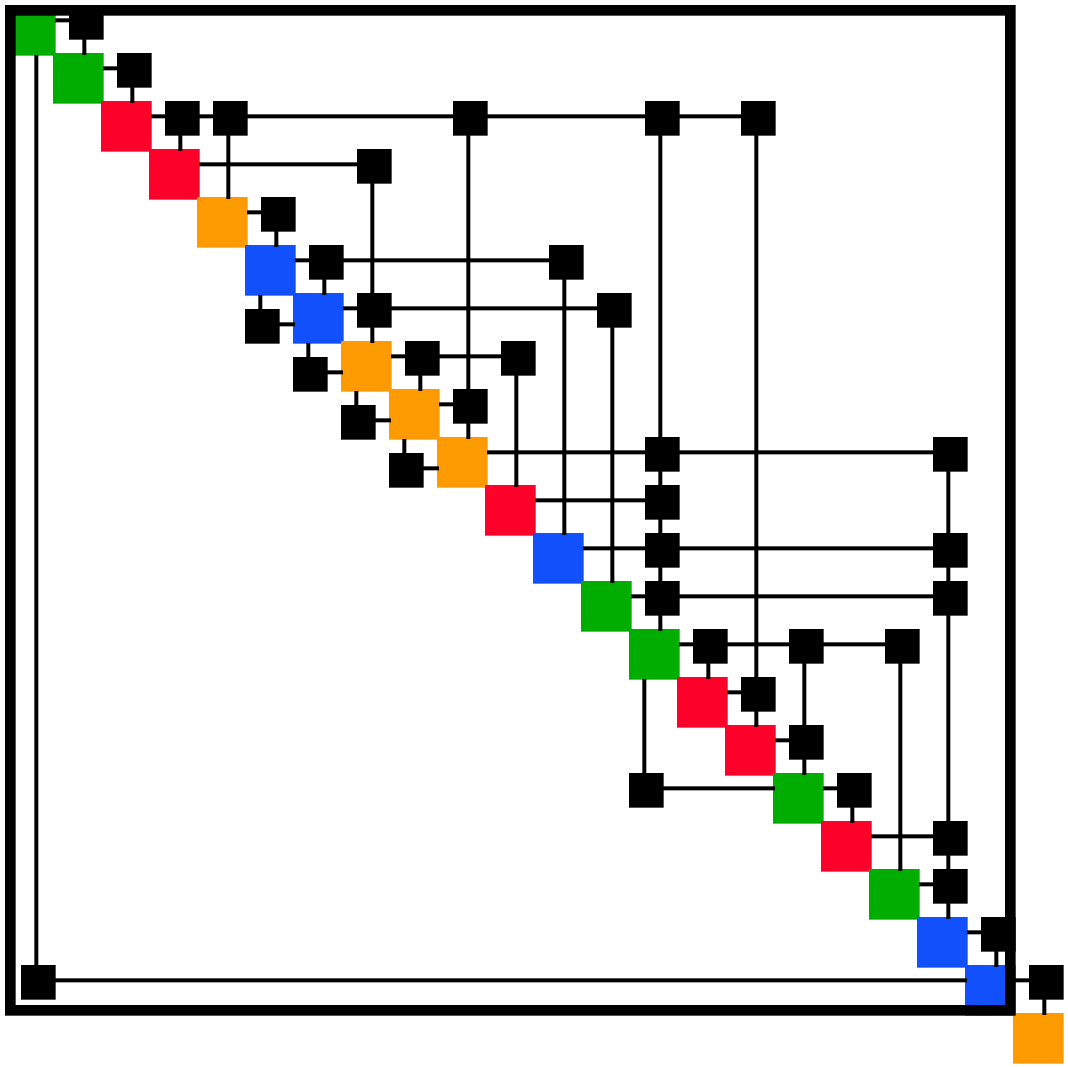
Process	Time	Cost
DYNMODL	30	30
STDMOCH	40	20
STRMODL	10	50
HANDQUL	10	50
STRMODE	10	50
GEOMDEV	50	10
AROSRVO	40	20
STRDYNA	50	10
CSVSANL	20	40
FAEROCH	20	40
INITDAT	40	20
RVSEDAT	30	30
MISPERF	30	30
VEHPERF	20	40
RAEROCH	30	30
AEROANL	20	40
PRESDEF	30	30
STRANAL	40	20
STRCTWT	50	10
WIANAL	40	20
AEROMDL	20	40
FINLDAT	20	40



Time - 21,340 Cost - 19,640

Design Cycle Time and Cost Reduced by GA

Process	Time	Cost
RVSEDAT	30	30
INITDAT	40	20
GEOMDEV	50	10
STRMODL	10	50
AEROMDL	20	40
AEROANL	20	40
PRESDEF	30	30
STRANAL	40	20
STRCTWT	50	10
WIANAL	40	20
STRMODE	10	50
RAEROCH	30	30
FAEROCH	20	40
STRDYNA	50	10
STDMOCH	40	20
DYNMODL	30	30
CSVSANL	20	40
HANDQUL	10	50
AROSRVO	40	20
VEHPERF	20	40
MISPERF	30	30
FINLDAT	20	40



Time 21,340 to 3,800

Cost 19,640 to 3,220

Future Plans

- Add constraints to the genetic algorithm.

- Modify the genetic algorithm to take parallel processing into account.

- Develop a web-based multidisciplinary framework monitoring and control system built around DeMAID/GA.

Summary

Several techniques for reducing design cycle time and cost by using the design structure matrix to aid in understanding and improving the process flow have been presented.

DeMAID/GA, including source and documentation, is available at no charge

http://fmad-www.larc.nasa.gov/mdob/users/rogers/